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Status and potentials of offshore wave energy resources in Chahbahar area (NW Omman Sea)

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ABSTRACT

Chahbahar area is located at the southern coasts of Iran in the Omman Sea. This paper examines possible examples of offshore wave power installations at Chahbahar area in the Omman Sea. The study aims at showing the physical possibilities of wave energy and electric power generation based upon point-absorbers and attenuator devices in the selected site. This site has been chosen to represent a range of offshore wave climates around Chahbahar area. Hindcasting data is used allowing estimations of wave energy generated and results show promising conditions in this area. Wave climate power density, or incident wave power per meter of WEC device reach a maximum value 24 kW/m with monthly maximum of 9.70 kW/m and annual average equals to 4.14 kW/m. We study power recoverable possibility for three different wave energy devices, based on their published power matrices; 750 kW Pelamis device, hypothetical modified 1500 kW Pelamis device and hypothetical 750 kW Single Point Absorber (SPA). Results show corresponding annual electric energy generation for this devices are 0.32 GWh, 4.9 GWh and 2 GWh respectively. Finally, we determine appropriate WEC device for selected site. Also, we propose a solution for some environmental problem.

Contents

1. Introduction

A warmer earth caused mostly by fossil fuels which bring about global warming may have consequences such as change in rainfall patterns, a rise in sea level, and various effects on plants, wildlife and human beings. Such effects have lead to serious concern among scientists and encouraged them to look to other resources for energy production.

Some of the energy resources which are available to mankind are called renewable energy. Their conversion has always played an important role in the lives of the inhabitants of the planet, and apart from a period of negligible length – relative to evolutionary and historical time scales – renewable energy sources have been the only ones accessible to mankind [1].

Wave energy is a renewable energy source with high power density, relatively high utilization factor, low visual impact and presumed low impact on environment compared to other renewable sources. Still, wave power has not yet been properly recognized partly due to lack of good technologies. Wave energy can bedivided into two potential extractable sources: open ocean swells

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Fig. 1. Chahbahar area [2].

and breaking waves. Open ocean swells result from the aggregated effects of wind currents blowing across the surface of the ocean. Swells result from the constructive interference of waves resolving into larger waves with bigger amplitudes and longer wavelengths. Breaking waves result from the incidence of these ocean swells on the seabed, as waves approach the coast [6]. The two primary sources of wave energy in Chahbahar area built up by local trade winds, swell generated by storms in the Indian Ocean.

The selected site located at the southern coasts of Iran at the Omman sea (25°06′00″N., 60°30′E.) (Fig. 1). Analytical software – Minitab 15.1.1.0 and Microsoft Excel 2002 – has been used for the analysis of the wave data and the calculation of the electric power density based on the device capture width matrix and the site annual wave climate. The calculations and estimations in the article are based on the assumption that the wave energy devices are a small point absorber and two attenuator devices.

The present study therefore seeks to estimation of the offshore wave energy potential for one point at Chahbahar area in the Omman Sea with potential technologies without going to the next level of detail – to determine an economic value for a project proposed in this area.

2. Estimated wave power

To develop the wave energy scatter diagrams for this initial resource specification, seastate parameter records were read to extract the significant wave height (H_s in m), and the peak wave period (T_p in s), which is the inverse of the frequency at which the wave spectrum has its maximum value for the measured sea state record. Based on these two parameters, the incident wave power (J in kilowatts per meter of wave energy device width, or kW/m) associated with each sea state record was estimated by the following equation:

$$J = 0.42 H_s^2 T_p \tag{1}$$

The 0.42 multiplier in the above equation is exact for any seastate that is well represented by a two-parameter Bretschneider spectrum, but it could range from 0.3 to 0.5, depending on the relative amounts of energy in sea and swell components and the exact shape of the wave spectrum. Although such an estimate, based solely on the parameters (H_s) and (T_p) is not exact, it was supposed adequate appropriate for this initial specification [3,4].

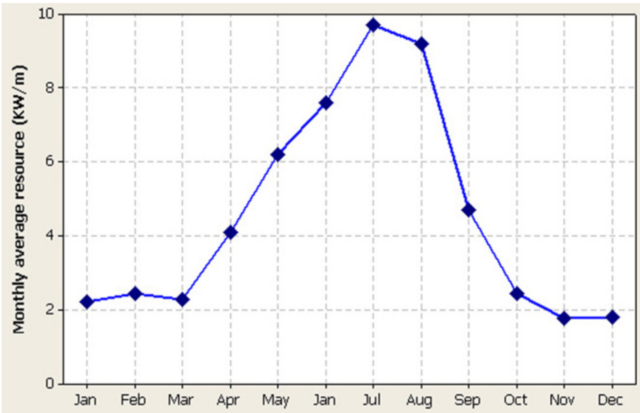

Fig. 2. Monthly average wave power flux (kW/m).

3. Wave energy resource data

The potential for the wave energy extraction can be obtained from analysis of the wave climate. Buoy data can give a general idea of the existing conditions as well as valuable information concerning some tendencies. Iran, this approach has some limitations especially due to the facts that the time period of the measurement and number of measurement station is in general limited and they are usually operating in shallow water. It is thus of main interest to develop a system that is able to predict the wave characteristics in various coastal locations, not necessarily considered as shallow water. That is why it is essential to predict the wave conditions with numerical models. An earlier attempt to this aim has been reported by Iranian Port and Maritime Organization (P.M.O.), where a wave atlas has been developed for Iran coasts (Iran Wave Atlas or IWA)[5]. In order to characterize the wave resource at the proposed site, the ISWM (Iranian Seas Wave Modeling) wave data output was chosen to obtain the wave data. 11 years of output data is available from this model.

One coastal site has been selected for detailed analysis of its wave power potential (Fig. 13). This site (25°06′N., 60°30′E.) has been chosen to represent a range of offshore wave climates around chahbahar area. A distance of 21.5 km offshore has been selected at site, providing water depths 100 m. Wave and wave power statistics have been extracted for this location using output data from the ISWM [5]. Fig. 2 shows the monthly average wave power flux (in kW/m) of the wave energy resource were created for one year (since 31 December, 2001 to 31 December, 2002) (Fig. 2) and used to estimate the power generation of wave energy conversion devices as described in the next part.

4. Extrapolation and wave power devices

There are various types of possible wave power devices. Devices, which extract energy from waves, are called 'oscillating water column' devices or 'overtopping' devices. Both are sometimes lumped together as 'terminator' devices. Devices, which extract energy from open ocean swells, are classified as either 'attenuator' devices or 'point absorber' devices. In this study we have use second set of devices [6,7].

4.1. Attenuator devices

An attenuator device is fundamentally a floating device, which works in parallel to the wave movement direction and effectively rides the crests and troughs of swell waves. Movement along the length of the device can be controlled to generate electric power. The most well known attenuator device is Pelamis, One developer that has previously published data for their WEC is Pelamis Wave Power, which published a 'power matrix' for the Pelamis 750 kW device (Fig. 3). A scaled 'commercial' version of the Pelamis power matrix was produced by University of Edinburgh to anticipate changes in the overall structure and performance as it developed towards full commercial realization (Fig. 4) [8].

4.2. Point absorbers

Perhaps the second most common generic device design – after the attenuator devices – are point absorbers. Point absorbers have a physical analogy to conventional maritime navigation buoys. They are usually largely submerged, axisymmetric and anchored to the seabed. To fulfill the scope of the study, and to better represent the spread of technologies under development, a generic Point absorber device was modeled resulting in the matrix shown in (Fig. 5) [6].

These power matrices has been used in this study to assess the wave energy potential of the selected site around the SS coasts of Iran. The methodology behind this approach is somewhat simplistic but functional [6]. This study examines the possible power recoverable for three different wave energy devices, based on their published power matrices.

Sig. wave height (m)																	
8	-	-	-	-	-	-	-	750	750	750	750	750	750	750	750	690	625
7.5	-	-	-	-	-	-	750	750	750	750	750	750	750	750	686	622	593
7	-	-	-	-	-	750	750	750	750	750	750	750	750	676	613	584	525
6.5	-	-	-	-	750	750	750	750	750	750	750	743	658	621	579	512	481
6	-	-	-	-	750	750	750	750	750	750	711	633	619	558	512	470	415
5.5	-	-	-	750	750	750	750	750	737	667	658	586	530	496	446	395	355
5	-	-	-	736	726	731	707	687	670	607	557	521	472	417	369	348	328
4.5	-	-	544	635	642	648	628	590	562	528	473	432	382	356	338	300	266
4	-	-	462	502	540	546	530	499	475	429	384	366	339	301	267	237	213
3.5	-	270	354	415	438	440	424	404	377	362	326	292	260	230	215	202	180
3	129	198	260	305	332	340	332	315	292	266	240	219	210	188	167	149	132
2.5	89	138	180	212	231	238	238	230	216	199	181	163	146	130	116	103	92
2	57	88	115	136	148	153	152	147	138	127	116	104	93	83	74	66	59
1.5	32	50	65	76	83	86	86	83	78	72	65	59	53	47	42	37	33
1		22	29	34	37	38	38	37	35	32	29	26	23	21	-	-	-
0.5	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle
	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
	Wave energy period (s)																

Fig. 3. Hypothetical 750 kW Pelamis power matrix. Values are in kW [8].

RMS wave height (m)																	
3	-	-	-	-	-	-	-	-	-	1500	1500	1500	1500	-	-	-	-
2.75	-	-	-	-	-	-	-	-	1500	1500	1500	1500	1500	1453	-	-	-
2.5	-	-	-	-	-	-	-	1500	1500	1500	1500	1500	1470	1319	1192	-	-
2.25	-	-	-	-	-	-	1500	1500	1500	1500	1500	1450	1350	1175	1039	900	-
2	-	-	-	-	-	1500	1500	1500	1500	1500	1450	1320	1180	1008	865	750	635
1.75	-	-	-	-	1500	1500	1500	1500	1500	1440	1277	1119	971	845	724	607	490
1.5	-	-	-	1450	1500	1500	1500	1460	1444	1253	1071	915	782	651	540	450	361
1.25	-	-	650	1258	1470	1450	1467	1299	1136	968	826	688	567	462	378	314	251
1	-	95	427	871	1116	1170	1106	969	834	688	558	449	366	297	242	201	161
0.75	-	53	241	525	730	769	709	605	493	397	317	254	206	168	137	114	91
0.5	-	24	108	237	336	358	326	274	222	178	142	114	93	75	61	51	41
0.25	-	5	27	62	88	94	85	72	58	47	33	22	18	14	10	5	0
0	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Wave energy period (s)

Fig. 4. Hypothetical 1500 kW Pelamis power matrix. Values are in kW [6].

RMS wave height (m)																	
3	-	-	-	-	-	-	-	-	-	750	750	750	695	598	515	444	383
2.75	-	-	-	-	-	-	-	-	750	750	750	738	637	548	472	407	351
2.5	-	-	-	-	-	-	-	750	750	750	750	671	579	498	429	370	320
2.25	-	-	-	-	-	-	750	750	750	750	694	604	521	449	386	333	288
2	-	-	-	-	-	750	750	750	750	699	616	536	463	399	343	296	256
1.75	-	-	-	-	710	750	750	731	679	612	539	469	405	349	300	259	224
1.5	-	-	-	546	609	645	650	627	582	524	462	402	347	299	257	222	192
1.25	-	-	347	455	507	537	542	522	485	437	385	335	290	249	214	185	160
1	-	73	222	364	406	430	433	418	388	349	308	268	232	199	172	148	128
0.75	-	41	125	273	304	322	325	313	291	262	231	201	174	150	129	111	96
0.5	-	18	55	135	203	215	217	209	194	175	154	134	116	100	86	74	64
0.25	-	5	14	34	70	107	108	104	97	87	77	67	58	50	43	37	32
0	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Wave energy period (s)

Fig. 5. Hypothetical 750 kW SPA power matrix. Values are in kW [6].

5. Statistical analysis of wave energy

Offshore wave data were obtained from eleven years (1992–2002) of ISWM (Iranian sea wave modeling) hindcast data, provided by the P.M.O. [5]. The annual histogram (since 31 December, 2001 to 31 December, 2002) of mean wave direction is shown in in Fig. 6. The plot clearly identifies one principal wave direction, south. To give a sense of the percent of waves that might contribute to power production a summary of the probabilities of occurrence, calculated for these four combinations, is presented in Fig. 6. These are calculated using four definitions of the area, starting from a 47° sector (between 111° and 158°), proceeding to sector (44° and 45°), and with the fourth sector encompassing a 45° angle. The range of sector sizes chosen for the analysis illustrates the sensitivity of the probability of occurrence to the effective capture sector for the plant. Using the lower threshold in terms of wave parameters to define the "principal wave direction" we see that 73.7% of such waves are from the 44° sector (in this case from 158° to 202°). If the incident sector size is restricted to 47° (111–158) or 45° (202–247), only 9.8% and 13.9%, respectively, of the waves satisfy the definition. Only 1.9% of the waves are included in the 45° sector (between 247° and 292°) and the portion of other wave direction is 0.7% (Fig. 6).

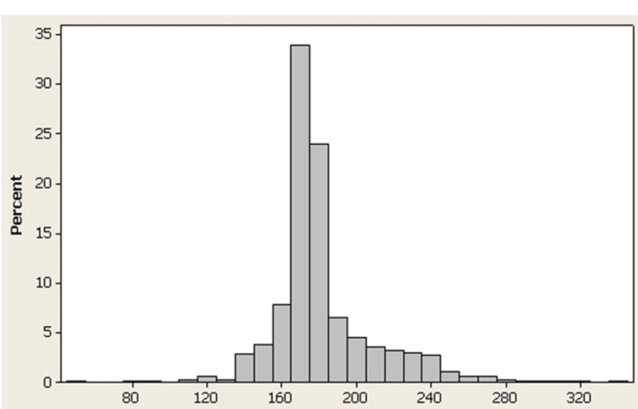

Fig. 6. Annual histogram of mean wave direction.

Whereas attenuator device should be install parallel form with principal wave direction, the scatter diagram for the annual occurrence of hours per sea-state for angel between 158° until 202° is shown in Figs. 7 and 8 with aim use in pelamis 750 kW and 1500 kW device respectively (Fig. 7) and (Fig. 8). Maximum annual occurrence of hours for pelamis 750 equals to 1141 h (for $H_s = 1$ m and $T_e = 8.5$ s) and maximum annual occurrence of hours for pelamis 1500 equals to 1157 h (for $H_{RMS} = 0.5$ m and $T_e = 8$ s). The scatter diagram for the annual occurrence of hours per sea-state is shown in Fig. 9 sake use point absorber (Fig. 9). Maximum annual occurrence of hours for SPA 750 kW equals to 1141 h (for $H_{RMS} = 0.5$ m and $T_e = 8$ s). Too, in above scatter diagram, we have selected a range of wave data that have been match with each device capture width matrix.

By multiplying each cell of the device performance scatter diagram (Figs. 3–5) with each corresponding cell in the hours of

Hs(m)	Te (sec) 5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	16	16	97	129	48	24	0	8	0	16	0	0	0
1.5	8	8	81	162	243	243	324	202	170	170	194	202	186	48	24	8	8
1	97	65	57	81	97	81	501	1141	404	291	331	0	0	0	48	32	32

Fig. 7. Maine site annual occurrence of hours per sea-state for pelamis 750 kW (between 158° and 202°).

H (m) RMS	Te (sec) 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	8	8	0	16	73	0	8	0	0	0	0	0	0	0	0
1.25	0	8	0	0	121	129	0	0	0	0	0	0	0	0	0	0
1	8	24	251	510	542	405	404	81	32	32	32	16	64	0	0	0
0.75	154	160	129	121	429	534	162	64	56	40	32	0	24	0	0	0
0.5	72	16	0	48	1157	1060	97	129	64	48	40	0	0	0	0	0
0.25	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0

Fig. 8. Maine site annual occurrence of hours per sea-state for pelamis 1500 kW (between 158° and 202°).

reoccurrence scatter diagram (Figs. 7–9) the total energy in each sea state was calculated. By summing up the three tables, the annual output (kWh/year) per device was derived.

The scatter diagram for the annual energy is shown in (Fig. 10), related to pelamis 750 kW, and the scatter diagram for the Annual energy is shown in (Fig. 11) related to pelamis 1500 kW. The scatter diagram for the annual energy is shown in (Fig. 12) related to single point absorber 750 kW.

The waves with $H_s = 1.2$ m and $T_p = 9.5$ s, have been known as energetic waves in chahbahar area and According to Budal's upper bound [9] one 300 kW single point absorber device with volume equals 300 m^3 and radius equals 4 m proposed for this area.

H (m) RMS	Te (sec) 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	6	6	0	12	54	0	6	0	0	0	0	0	0	0	0
1.25	6	6	6	72	240	156	30	12	0	24	12	0	0	0	0	0
1	78	36	210	336	336	264	300	60	24	30	12	18	48	0	0	0
0.75	222	162	108	108	348	594	162	60	42	36	24	6	24	0	0	0
0.5	78	12	0	30	1272	1116	102	108	42	6	30	0	0	0	0	0
0.25	6	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0

Fig. 9. Maine site annual occurrence of hours per sea-state for SPA 750 kW.

Hs(m)	Te (sec)																	Total kWh per year
	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	2368	2448	14744	18963	6624	3048	0	832	0	1328	0	0	0	50355
1.5	256	400	5265	12312	20169	8748	27864	16766	13260	12240	12610	20259	9858	2256	1008	296	264	163831
1	0	1430	1653	2754	3589	3078	19038	42217	14140	9312	9599	0	0	0	0	0	0	106810
Sum	256	1830	6918	15066	26126	14274	61646	77946	34024	24600	22209	21091	9858	3584	1008	296	264	320996

Fig. 10. The scatter diagram for the annual energy (kWh) for pelamis 750 kW.

H (m) RMS	Te (sec)																Total kWh Per year
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	11600	0	24000	109500	0	11552	0	0	0	0	0	0	0	0	156652
1.25	0	5200	0	0	175450	189243	0	0	0	0	0	0	0	0	0	0	369893
1	760	10248	218621	569160	634140	447930	391476	67554	22016	17856	14368	5856	19008	0	0	0	2418993
0.75	8374	38560	67725	88330	329901	378606	98010	31552	22232	12680	8128	0	4032	0	0	0	1088130
0.5	1728	1728	0	16128	414206	345560	26578	28638	11392	6816	5760	0	0	0	0	0	858534
0.25	0	0	0	0	0	1360	0	0	0	0	0	0	0	0	0	0	1360
Sum	10862	55736	297946	673618	1577697	1472199	516064	139296	55640	37352	28256	5856	23040	0	0	0	4893562

Fig. 11. The scatter diagram for the annual energy (kWh) for pelamis 1500 kW.

H (m) RMS	Te (sec)																Total kWh per year
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	3276	0	7740	35100	0	3492	0	0	0	0	0	0	0	0	49608
1.25	0	2082	2730	36504	128880	84552	15660	5820	0	9240	4020	0	0	0	0	0	289488
1	5694	7992	76440	136080	144480	114312	125400	23280	8376	2772	3216	4176	9552	0	0	0	661770
0.75	9102	20250	29484	32832	112056	193050	50706	17460	11004	8316	4824	1044	3600	0	0	0	493728
0.5	1404	660	0	6090	273480	242172	21318	20952	7350	924	4020	0	0	0	0	0	578370
0.25	30	0	0	0	0	648	0	0	0	0	0	0	0	0	0	0	678
Sum	16230	30984	111930	211506	666636	669834	213084	71004	26730	21252	16080	5220	13152	0	0	0	2073642

Fig. 12. The scatter diagram for the annual energy (kWh) for SPA 750 kW.

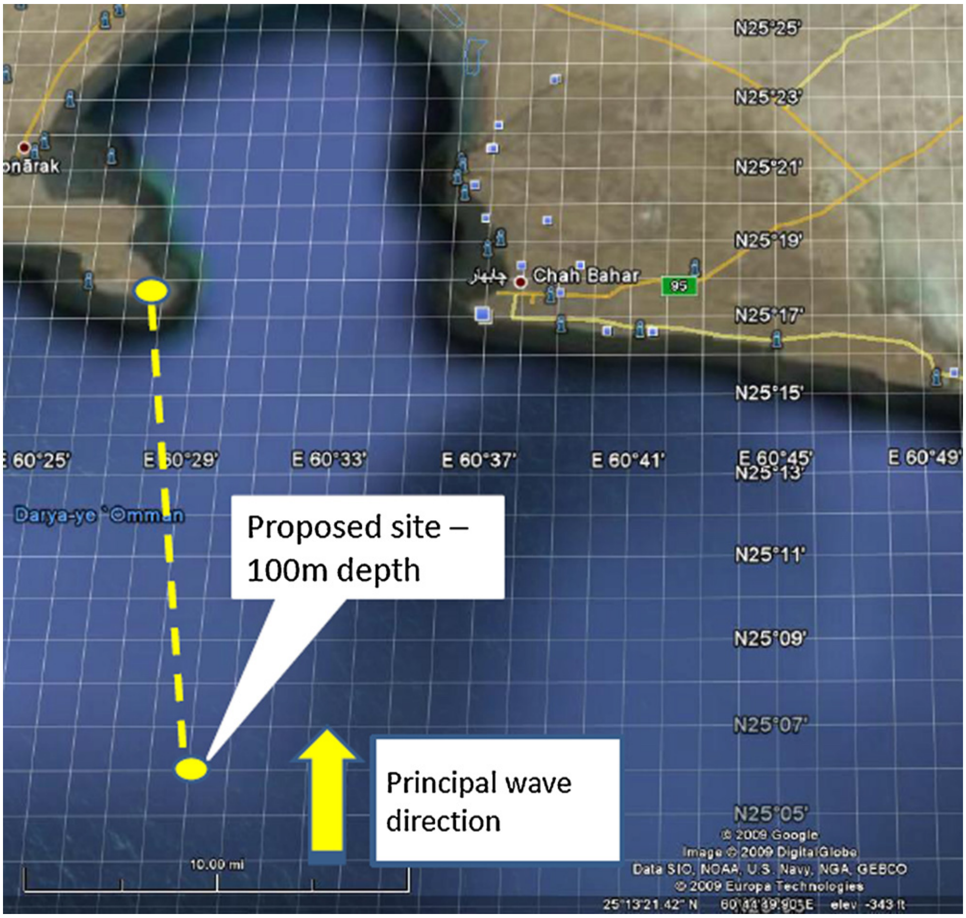

Fig. 13. The selected site [2].

6. Interaction with marine life and tourism

1. Interaction and compatibility with marine life

   Pinnipeds (seals and sea lions) may attempt to haul out on floating wave energy devices with low freeboard. This could cause unforeseen interaction between specific populations of these species and human activities [10]. We propose killer whale-like cover for WEC devices. If we use this cover, Pinnipeds will not Approach to WEC devices, like scarecrow function in farm.
2. Compatibility and impacts on recreation and tourism

   The most important potential influence of wave energy on recreation and tourism is due to visual impact, which is likely to prove an important obstacle to large-scale deployment of wave energy schemes in areas of tourism or aesthetic importance [10]. Killer whale-like cover or other appropriate cover are solution for these problems.

7. Conclusion

Chahbahar area is an important shipping and navigation area in the Omman Sea. Should be recognized as a technical potential and presents a possible scheme for a large-scale roll-out, whereas the result from the present work is more to be considered as gross wave energy potential for one site in the Omman Sea. The case shown here illustrate three devices and devices were chosen mainly based on the power flux in the waves. Thorough economical analysis is required prior to any real installation plans. We have employed statistical software, for estimating power density at the selected site, during one-year (since 31 December, 2001 to 31 December, 2002). Wave climate power density, or power incident per meter of WEC device reaches a monthly maximum of 9.70 kW/m and annual average equals to 4.14 kW/m. Two significant conclusions emerge from the calculation of output power from arrays of three of the devices:

1. For single Pelamis 750 kW device, average electric power generation would be 0.32 GWh, for single Pelamis 1500 kW device, average electric power generation would be 4.9 GWh and for single point absorber (SPA), average electric power generation would be 2 GWh. The 750 kW attenuator devices produce between one-sixth of the power of the point absorber devices and between one-fifteenth of the output power of the 1500 kW attenuator devices. The waves with $H_s = 1.2$ m and $T_p = 9.5$ s, have been known as energetic waves in chahbahar area therefore a 300 kW single point absorber device with volume equals 300 m^3 and radius equals 4 m proposed for this area.
2. We propose killer whale-like cover for Wec devices. If we use this cover, Pinnipeds will not Approach to WEC devices, like scarecrow function in farm. killer whale-like cover and other appropriate cover create a beautiful view and compatibility with environment.

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